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Tungsten-based Electrocatalyst and Fuel Cell Containing Same

First Named Inventor: Joel B. Christian

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Attached Files:

specification	03-2-308provisional.xml
bibd-transmittal	03-2-308provapds.xml
fee-transmittal	03-2-308provfee.xml

[redacted]

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SPECIFICATION

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Tungsten-based Electrocatalyst and Fuel Cell Containing Same

Background of Invention

[0001] Transition metal carbides have been studied as catalysts since 1959. In 1965, AEG-Telefunken discovered that tungsten carbide could potentially replace platinum as an anode catalyst for acid style fuel cells. These investigators ran a fuel cell for over 30,000 hours with an anode catalyst composed of tungsten carbide. Since that time, five tungsten compounds have been identified as potential anode and cathode catalysts for low-temperature acid fuel cells: WC, W_2C, WO_3:Pt, Na_xWO_3, W-POM.

Summary of Invention

[0002] The catalyst of this invention is a non-stoichiometric tungsten compound, $H_{0.53}WO_3$, which may be used as both anode and cathode electrocatalyst for acid-style low-temperature fuel cells.

[0003] The method used to make the catalyst is a novel route to hydrogen tungsten bronze which involves first creating an ammonium bronze, $(NH_4)_{0.33}WO_3$. This material is stable and is formed easily by heating AMT to 490 ° C in an inert atmosphere. This method has many practical improvements in the art, including eliminating extra water and oxygen from the compound, and forming a stable intermediate for further catalyst synthesis. This intermediate can also be applied to synthesis for other tungsten-based catalyst applications, including hydrocracking and NO_x control catalysts.

Brief Description of Drawings

[0004] Fig. 1 is an x-ray diffraction pattern of the catalyst of this invention.

[0005] Fig. 2 is a plot of the half-cell performance of the catalyst of this invention.

[0006] Fig. 3 is graph of the voltage-power performance of a fuel cell wherein both the anode and cathode are comprised of the tungsten-based catalyst of this invention.

[0007] Fig. 4 is a graph of the operational performance of a fuel cell at various resistive loads wherein both the anode and cathode are made with the tungsten-based catalyst of this invention.

Detailed Description

[0008] The tungsten-based catalyst of this invention was synthesized and tested by XRD, voltammetry, and fuel cell operation. Figure 1 shows the X-ray powder diffraction pattern of the carbon-supported tungsten-based electrocatalyst used for fuel cell demonstration. The pattern fits PDF 72-1712, $H_{0.53}WO_3$. Figure 3 shows the performance of a fuel cell wherein both the anode and cathode have been fabricated with the tungsten-based catalyst of this invention.

[0009] *EXAMPLE 1*

[0010] Three carbon rods (Bay Carbon AGKSP 0.242x12) were soaked in a solution of ammonium metatungstate (AMT) (OSRAM SYLVANIA, catalyst grade, 1600g/l) for three days. The rods were placed in a 9" Inconel boat, along with a small amount of AMT in a graphite boat as a visual indicator. The boats were placed in a tube furnace and sealed at a pressure of 5 inches water gauge in flowing Argon.

[0011] The furnace was heated to 200 ° C and held until the AMT powder appeared green, indicating the material had dried. The temperature was raised to 490 ° C under argon and held overnight. The samples appeared dark blue, indicating that an ammonium tungsten bronze had formed.

[0012] The gas flow was changed to 1 lpm H2 and 1 lpm Ar to provide a partially reducing atmosphere. The appearance of the material was monitored, and the AMT sample appearance changed color with a moving interface, changing from blue to gray. After 7.5 hours, the furnace was cooled. The furnace was purged and the samples removed for analysis. One rod was labeled "S5." Figure 2 shows the ½ cell performance characteristic for sample S5.

[0013] *EXAMPLE 2*

[0014] Four carbon rods (Bay Carbon AGKSP 0.242x12) were soaked in a solution of ammonium metatungstate (AMT) (OSRAM SYLVANIA, catalyst grade, 1600g/l) for three days. The rods were placed in a 9"Inconel boat, along with two other boats, one ceramic boat containing 20wt% AMT on a high-surface-area carbon powder, Cabot XC-72, and one ceramic boat containing a small amount of AMT as a visual indicator. The boats were placed in a tube furnace and sealed at a pressure of 5 inches water gauge in flowing Argon.

[0015] The furnace was heated to 120 ° C and held until the AMT powder appeared green, indicating the material had dried. The temperature was raised to 490 ° C under argon and held overnight. The samples appeared dark blue, indicating that an ammonium tungsten bronze had formed.

[0016] The gas flow was changed to 1 lpm H_2 and 3.5 SCFH Ar to provide a partially reducing atmosphere. The appearance of the material was monitored, and the AMT sample appearance changed color with a moving interface, changing from blue to gray. After 1.75 hours, the furnace was cooled. The furnace was purged and the samples removed for analysis. One rod was labeled "S6." X-ray diffraction of the center boat containing 20%W on XC-72 to start showed the material to be $H_{0.53}WO_3$, matching PDF 72-1712, file L242823.MDI.

[0017] *EXAMPLE 3*

[0018] The tungsten bronze supported on XC-72 from example 2 was fabricated into a 5cm ² membrane-electrode-assembly (MEA). They were teflon-bonded into both catalyst layers of a 5-layer MEA with carbon paper and Nafion™ 117 membrane, then assembled into a 5cm ² fuel cell and operated with hydrogen and air at room temperature with a various fixed resistive loads to obtain the operation curves in Figure 4.

Claims

[c1] An electrode for a fuel cell comprising $H_{0.53}WO_3$.

[c2] A fuel cell comprising an anode and cathode having a catalyst wherein the catalyst consists of a tungsten-based compound.

Tungsten-based Electrocatalyst and Fuel Cell Containing Same

Abstract of Disclosure

The catalyst of this invention is a non-stoichiometric tungsten compound, $H_{0.53}WO_3$, which may be used as both anode and cathode electrocatalyst for acid-style low-temperature fuel cells.

Figures

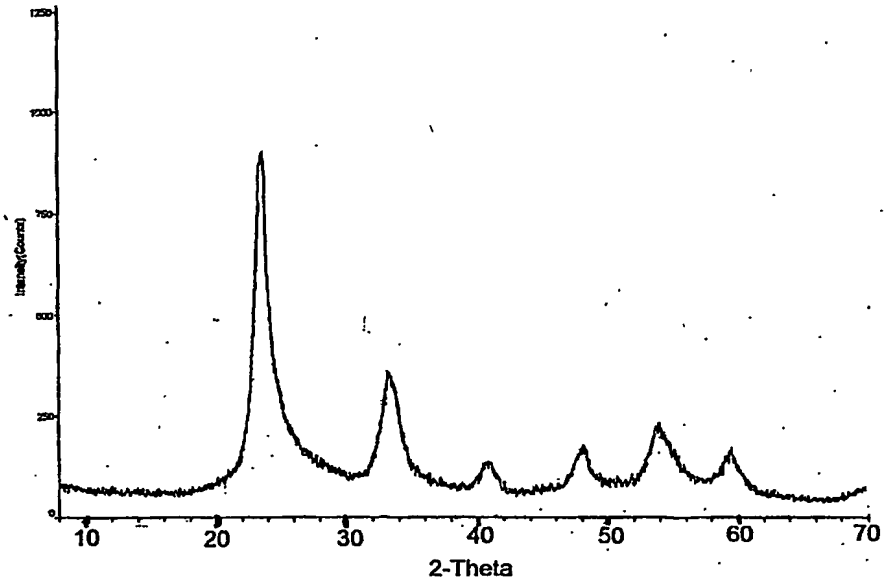

FIG. 1

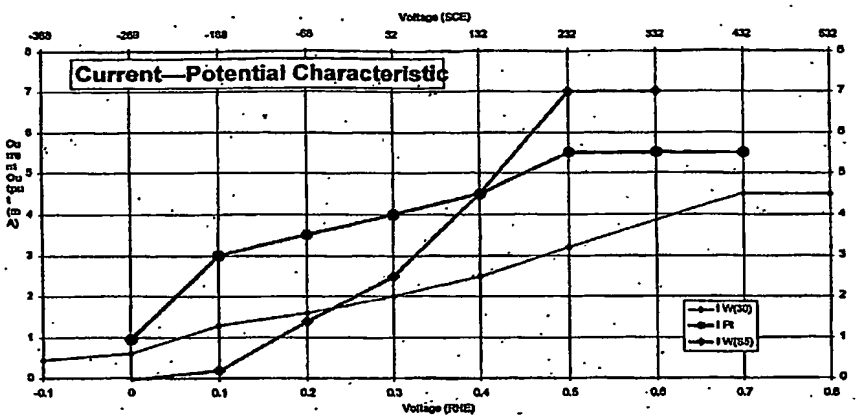
Current—Potential Characteristic
Voltage (SCE)
Voltage (RHE)
I W(30)
I Pt
I W(35)

FIG. 2

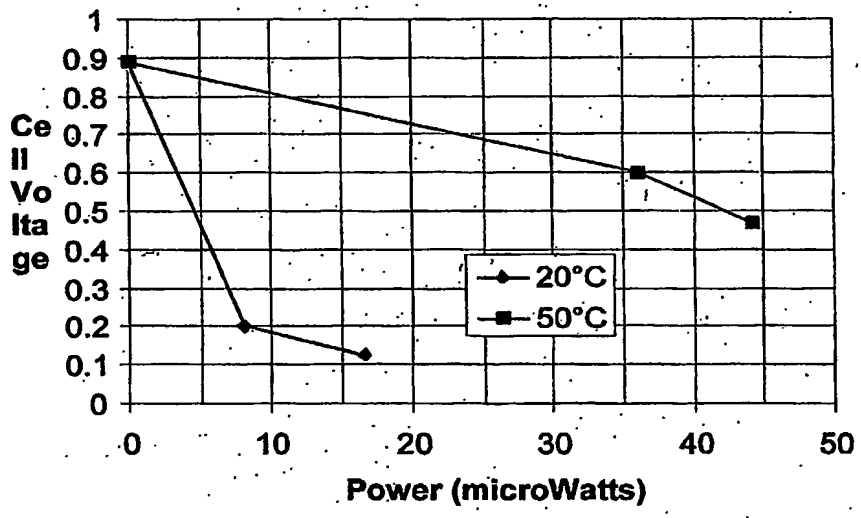
Cell Voltage
Power (microWatts)
20°C
50°C

FIG. 3

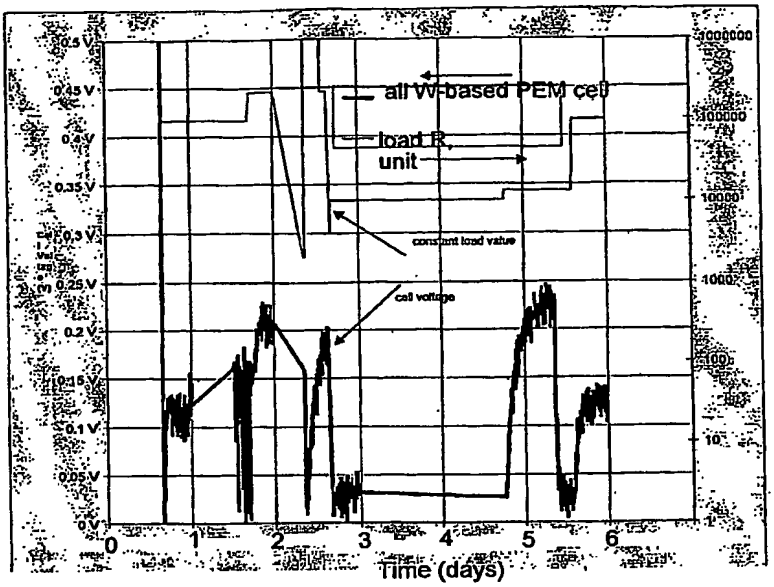
all W-based PEM cell
load R, unit
constant load value
cell voltage
0.5 V
0.45 V
0.4 V
0.35 V
0.3 V
0.25 V
0.2 V
0.15 V
0.1 V
0.05 V
0 V
1000000
100000
10000
1000
100
10
1
0
1
2
3
4
5
6
Time (days)

FIG. 4